GIS Based Terrain Modelling of the Area NW of Karimnagar, Southern India

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***Abstract*-GIS based DEM has been used in conjunction with detailed field work to extract geomorphic features and their control on drainage pattern in a part of Karimnagar granulite terrain (KGT), Southern India. Study revealed that the Precambrian metamorphic terrain has an uneven rugged topography represented by raised hillocks forming different patterns surrounded by flat and ponded low lying areas. These distinctly different types of geomorphic domains are characterized by different slope aspects, channel patterns, drainage texture and stream character. Channel alignment and presence of two generation folds present in the country rocks of the study area indicate to a strong structural control on the geomorphic evolution of the area, and that calls for a further detailed structural studies to understand basin evolution in conjunction with metamorphic episodes the rocks of the area has underwent. The purpose of present work is to provide a GIS based terrain modelling to suggest strong tectonic control on the existing geomorphology.**

Keywords-Digital Elevation Model, Rugged Topography, Karimnagar Granulite Terrain, Southern India

I. INTRODUCTION

The investigated area covering more than 200 sq kms north-west of Karimnagar town, district Karimnagar, Andhra Pradesh lies between the 785'E & 18˚45'N to 79˚00'E & 18˚30'N (SOI toposheet no.56J/14). Karimnagar lies in NNE direction of Hyderabad at a distance of about 150 kilometers and is well connected to nearby areas both by road and train routs (Fig. 1a, b). The country rocks comprising Precambrian Karimnagar granulites contain quartz-free sapphirine-spinel bearing granulites, kornerupine-bearing granulites, mafic granulites, orthopyroxene-cordierite gneisses, charnockites, amphibolites, dolerite dykes, granite gneisses, quartzites and banded magnetite quartzite. These rocks have been investigated by different workers for mineralogical, pertological details, radiometric dating and recently some rocks with new minerals not earlier reported have been identified [1], [2], [3], [4], [5], [6], [7] (Fig.1c). Unfortunately however, metamorphic rock exposures in the area are scanty and normally found in the form of isolated hillocks or discrete blocks providing no opportunity for detailed structural and geomorphological analysis.

Never the less, quantitative measurements on drainages and relief features for morphometric studies have been used by many workers including [8], [9], [10], [11], [12], [13], [14], [15] etc. using the techniques of remote sensing and GIS in different drainage basins.

However, GIS based geomorphological investigation in the Karimnagar granulite terrain (Southern India) has received less attention in the past and therefore in the present communication geomorphological modeling of the area NW of Karimnagar has been attempted based on GIS. The main objective of the present study is to generate DEM (digital elevation model) and digitized drainage map of the part of the Karimnagar area of Andhra Pradesh to calculate the slope aspects, slope direction, and determine geomorphic features and drainage textures using GIS software. In addition an attempt has been made to correlate the geomorphic features with probable tectonic episodes.

II. GEOLOGY OF THE AREA

The Karimnagar area lies in north-eastern part of the Eastern Dharwar Craton located south of Permocarboniferous sedimentary formations of Godavari Graben (Fig.1b). The Karimnagar granulite Terrain (KGT) is predominantly made up of massive granite gneisses, granites and charnockites in which quartz-free granulites and other high-grade rocks occur as enclaves (Fig. 1c). The Dharwar Craton consists of NNW and northerly trending greenstone-granite belt surrounded by granite-gneisses. It is divided into Western Dharwar Craton (WDC) and Eastern Dharwar Craton (EDC) which is separated by N–S

trending thrust located about 25 kilometers west of the N–S trending arcuate Closepet Granite. The oldest reported metamorphic event in the area is M1 (~3.0 Ga) which affected the Basement Gneiss (3.58–3.4 Ga) in the Western Block [16], Peninsular Gneiss (~3.0 Ga) and enclaves of older supracrustals (Sargur Group, 3.2–3.1 Ga, [16] and references therein). The later M2 metamorphic event affected the older rocks mentioned above as well as the greenstone belts (2.7–2.6 Ga) of the Dharwar Craton and it was followed by emplacement of the Chitradurga Granite (2.6 Ga) in the western block and the Closepet Granite and granitoids of the Kolar belt in Eastern Block at 2.5 Ga [17], [18]

The metamorphic rocks of the EDC show an increase in grade of metamorphism southward from greenschist (Sandur, Hospet and Ramgiri belts east of Closepet Granite) to amphibolite facies (Kolar belt) to granulite facies (Krishnagiri–Dharmapuri area).The pelitic schists are characterized by the presence of andalusite in the greenschist facies, andalusite/sillimanite-cordierite in the amphibolite facies and sillimanite-cordierite±garnet in granulite facies, thus displaying andalusite-sillimanite type of facies series. This is in contrast to the WDC which is chracterised by the Kyanite-sillimanite type of facies series [19], [20]. The Karimnagar granulite terrain is important because of the

presence of high-grade granulite facies rocks further NE of the greenschist belt of the EDC.

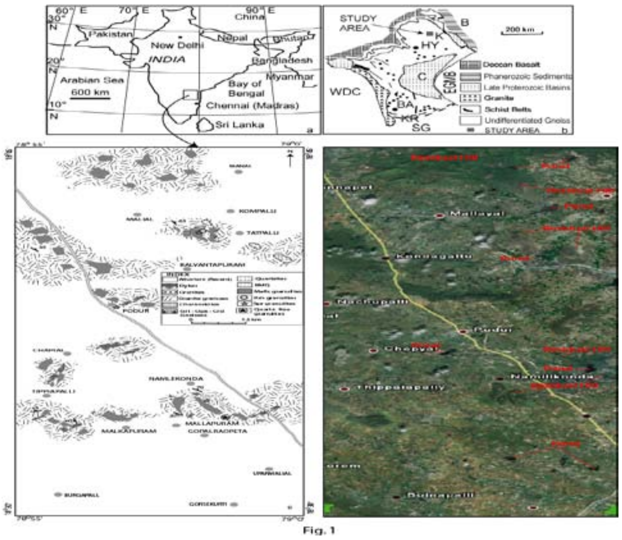

Fig.1 (a) Reference map of India, (b). Lithological patterns for Precambrian rocks of the Eastern Dharwar Craton along with craton boundaries. The abbreviations used are: WDC – Western Dharwar Craton, SG – Southern Granulite, EGMB – Eastern Ghats Mobile Belt, B – Bastar Craton, Hy – Hyderabad, K – Karimnagar, C – Cuddapah, BA – Bangalore, KR – Krishnagiri (c). Geological map of the area NW of Karimnagar (modified after Prakash and Sharma , 2011), (d). Google satellite picture of the study area with geomorphic features.

Because of difficult outcrop situation and scarcity of exposures, comprehensive structural data base is not available. However, some general strike trends can be measured in gneisses and biotite-schists on the basis of existing foliations. In general very gently dipping rocks seem to strike in NW–SE with a variation between NNW–SSE to WNW–ESE. The overlying high-grade supracrustal rocks are also found as highly attenuated and dismembered units restricted as enclaves within granite-gneisses and charnockites. In such a terrain, remote sensing and GIS based modeling may be of immense help to provide synaptic view to understand structural style, associated geomorphic elements and overall tectonic evolution of the area.

III. MATERIALS AND METHODS USED IN PRESENT STUDY

In the present study SOI toposheet no.56J/14 (year, 1990; scale: 1:50,000) has been used to digitize contour values, drainages and spot heights to generate DEM of the area and analysis of drainage configuration. Extensive field work has been done to provide ground check validity to DEM and drainage patterns.

The contour map of the area has been prepared by digitizing contours (of 20m intervals) using GIS software. The contour ranges from 280 to 500 feet at the interval of 20 feet. The spot heights given in toposheet have been digitized to create spot height point map.

The DEM of the study area (spatial resolution of 15m) has been prepared by interpolation of rasterised segment contour map and spot height point map (Fig. 2). This DEM is useful tool to interpret the geomorphic and tectonic features of any area in conjunction with satellite data and ground truthing. Colshadow map of the study area is prepared from DEM to visualize three dimensional view of the study area (Fig. 3). Slope map of the study area has been prepared (both in degree and direction) with the help of DEM (Fig. 4, 5). The digitized drainage map is prepared under GIS software. Ordering of drainages has been done on the basis of Horton [21] (Fig. 6).

IV. RESULT AND DISCUSSION

The prepared DEM (Fig.2) shows an uneven topography with elevated areas surrounded by low lying areas and gently sloping surfaces. Highest elevation points rising to 400 to 460 m asl (above sea level) are located in the mid-western side of the area surrounded by points of medium elevation having heights of 300 to 400m asl (Fig 2). Relatively low level elevations are conspicuously present north-eastern and south eastern parts of the area. Field check revealed that these high elevation reliefs of the study area are made up of granite and granite gneisses while low reliefs are characterized by garnet-cordierite gneisses. Interestingly, sapphirine bearing granulites are confined low relief area between medium to high relief elevation points (300–460m asl). In general, area shows a rugged topography where medium to high elevations are present forming different patterns. In the north of the area the high relief of the area is accumulated in circular form, while it is arcuate shaped in the mid-western part and narrow linear rugged topographic relief in the southern part of area (Fig.3, 4, 5). The clear evidences of rugged topographic relief has been easily recognized and verified using both slope direction and slope amount map created by DEM processing and Colshadow map.

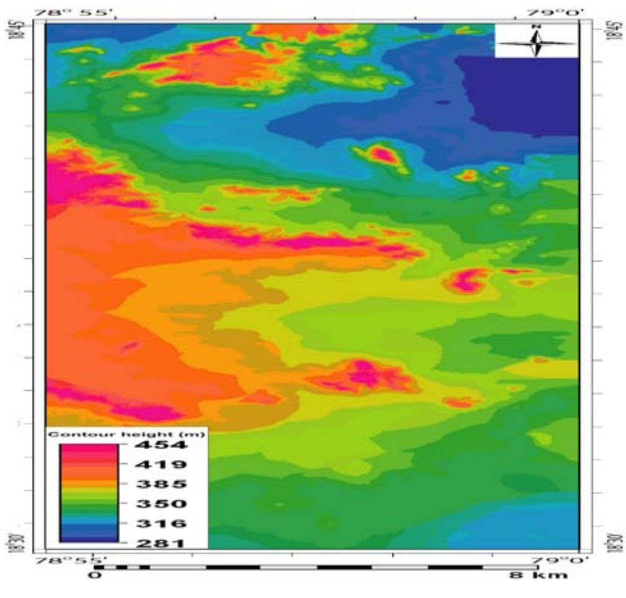

Fig. 2 Digital Elevation Model (DEM) of the study area

Aspect slope categorization has been done by using following category: 22.5° (North); 67.5°(North-East); 112.5° (East); 157.5° (South-East); 202.5° (South); 247.5° (South-West); 292.5°

(West); 337.5° (North-West); 361° (North2). By the slicing of slope map using above boundary slope direction maps has been prepared (Fig. 5).

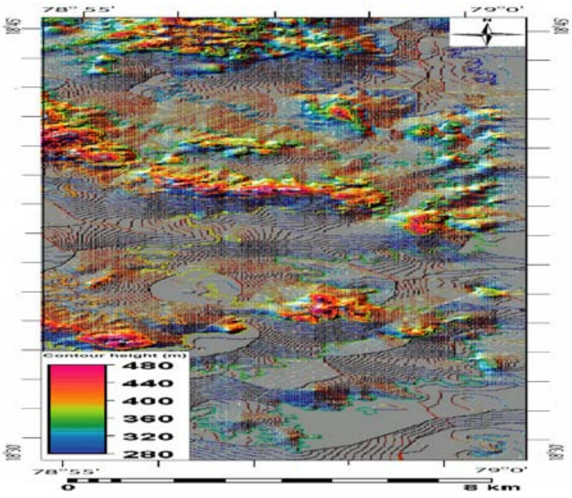

Fig. 3 Colshadow map showing three dimensional view of the study area

Slope analysis has shown that the maximum slope is around 27° and is associated with high -elevated regions. Whereas areas located south of high elevation regions are almost flat and low-lying without any conspicuous slope aspect. However, slope directions are highly variable showing no discernible pattern (Fig. 5). Drainage map analysis in conjunction with slope maps also suggests that the slope of the region in hilly area is not unidirectional but multidirectional (Fig. 4, 5, 6).

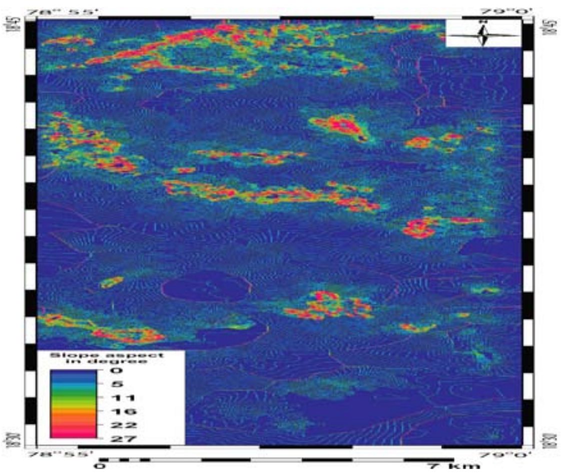

Fig.4 Slope map (in degree) of the study area

The drainage map of the area shows that most of the stream flow away from small hills forming radial pattern (Fig. 6). As far as the orders of streams are concerned, the highest stream order is eight and only one such stream is present. Three streams of seventh order are present. Both seventh and eight order streams are present in the western part of the area. Lower order streams are numerous. Drainage texture of the area varies from location to location. The areas near the hills have high fine drainage texture while the plains have very coarse drainage texture. The fine texture is present due to steep slope of the residual hills flanks. The coarse texture of the streams seems have structural control and may be attributed to jointed and fractured granulitic terrain. The first and second order streams have very low channel sinuosity while the streams of third and forth orders have highest channel sinuosity in the study region. First order streams are numerous but of small stream length. Third and forth, order streams are comparatively less in numbers but have long stream length. Most of the first and second order streams flow radial in the study region. The streams of higher order flow along the nearly level areas.

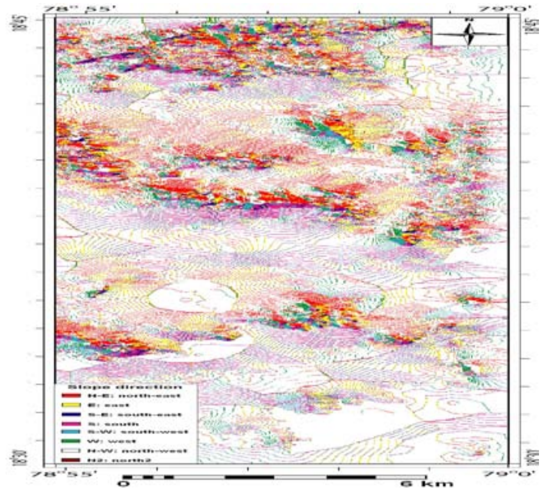

Fig. 5 Slope map (direction) of the study area

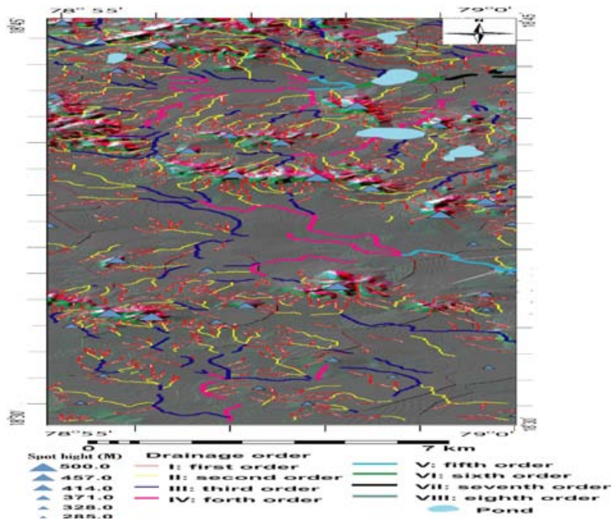

Fig. 6 Map showing ponds and drainage network of the study area

Colshadow map is also revealing a rugged topography in the area (Fig 3). During field work to validate the DEM data, it has been found that whole study area is characterized by uneven topography (Fig. 7a, b). Residual hills surrounded by pediment plains are prominent geomorphic feature of area (Fig. 7c). The prominence of radial pattern of drainage in the area is another evidence of existence of residual hills (Fig. 6).

The low lying areas are often occupied by small and large ponds (Fig.1d, 3).The conspicuous presence of several ponds and residual hills in granite and granite-gneiss terrain (Fig 1d, 7d) may be the result of multiphase deformational activity on regional scale since Precambrian time [15]. Testimony to intense tectonic deformation is the tight isoclinal folds with curved axial planes present in the Malial area (Fig. 7 e, f).

Fig. 7 Field photographs showing (a,b) Residual hills in the study area (c) Residual hills and pediment plains,(d) Pond near Mallial, (e,f) Tight isoclinal fold in granite gneisses near Mallial.

Such structural features suggest strong tectonic control on the existing geomorphology. Analysis of folds shows at least two phases deformation similar to type 1 fold superposition pattern of Ramsay [22]. Such deformation when two fold directions are perpendicular to each other may give rise domes surrounded by basins. It appears that a large number of residual hills represent domal areas and low lying ponded areas are the natural sites in the basinal parts. To validate the

view detailed structural investigation is further required in the back ground of metamorphic episodes present in the study area.

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